INSTRUCTION MANUAL

Model 207 Temperature and Relative Humidity Probe

Revision: 2/94

Warranty and Assistance

The **207 TEMPERATURE AND RH PROBE** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

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CAMPBELL SCIENTIFIC, INC.
RMA#_____
815 West 1800 North
Logan, Utah 84321-1784

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MODEL 207
TEMPERATURE AND RELATIVE HUMIDITY PROBE

1. GENERAL

The Model 207 probe contains a Phys-Chem Scientific, Inc. PCRC-11 RH sensor and a BetaTHERM 100KA61 thermistor. The probe is designed to be housed in the 41004-5 12 Plate Gill Radiation Shield, and has a standard 6 foot lead length. Extra lead lengths are available up to 1000 feet. Don't extend lead lengths by adding wire to the pigtail. Measurement errors will result.

> **CAUTION:** Never apply a DC voltage to this sensor. The RH chip will be polarized, causing irreparable damage. Do not measure the sensor resistance with a common multimeter. See the attached handling notes provided by Phys-Chem Scientific, Inc.

2. ACCURACY – TEMPERATURE SENSOR

The overall probe accuracy is a combination of BetaTHERM's interchangeability specification, the precision of the bridge resistors, and the polynomial error. In the "worst case" all errors add to an accuracy of ±0.4°C over the range of -36° to 49°C. The error is typically less and can be reduced with a single point calibration. The major error component is the ±0.2°C inter-changeablility specification of the thermistor from 0 to 70°C (±0.5°C at -40°C). The interchangeability error is predominantly offset and can be determined with a single point calibration. Compensation can then be done with an offset entered in the measurement instruction. The bridge resistors are 0.1% tolerance with a 10ppm temperature coefficient. Polynomial errors are tabulated in Table 2-1 and plotted in Figure 2-1.

TABLE 2-1. Polynomial Error

-40 to +56	<1.0°C
-38 to +53	<0.5°C
-24 to +48	<0.1°C

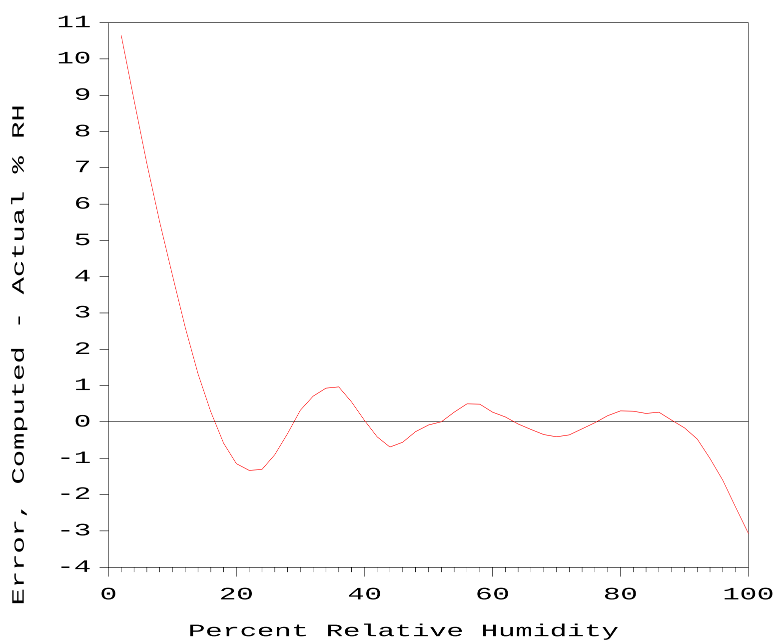

FIGURE 2. Relative Humidity Sensor Polynomial Error Curve

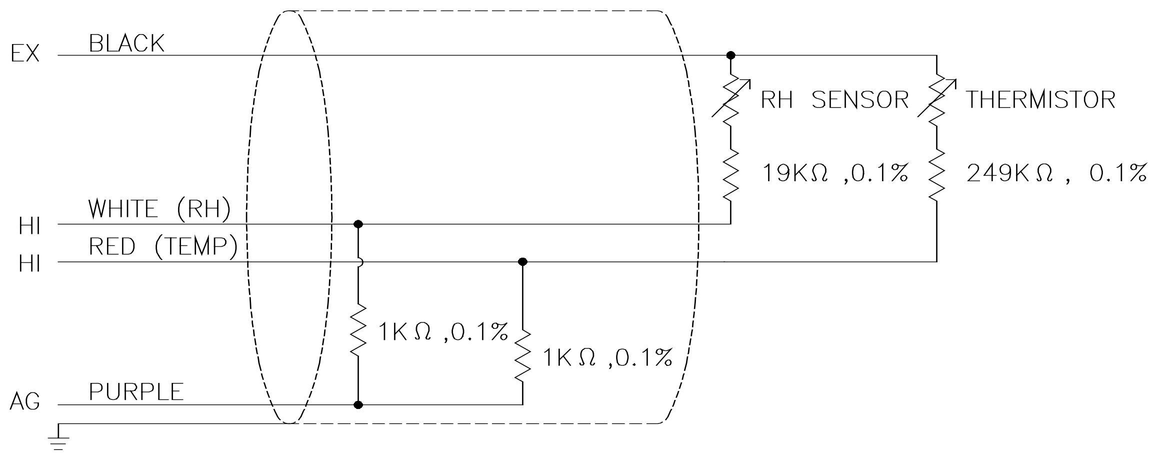

FIGURE 3. 207 Probe Schematic

3. ACCURACY - RH SENSOR

The overall sensor accuracy is a combination of the RH sensor, the precision resistors, and a polynomial error. The combined RH sensor accuracy is typically better than ±5% over the 12 to 100% RH range.

The bridge resistors are 0.1% tolerance with a 10ppm temperature coefficient. The polynomial errors are tabulated in Table 2 and also plotted in Figure 2.

TABLE 2. RH Polynomial Errors

RH Range (%)	Error (%)
12 - 100	<3
25 - 94	<1

The computed RH value is temperature compensated as follows:

$$RH = RH_O + 0.36(25-T)$$

where RH is the temperature compensated relative humidity, RH_O is the measured relative humidity as computed by the polynomial, and T is the air temperature.

4. WIRING

The 207 schematic is shown in Figure 3. The 207 probe uses two single ended analog channels, the red (temperature) and white (RH) leads can be connected into any HI or LO inputs.

The black lead connects to any excitation channel. Both sensors in the 207 share a common excitation line. Since one excitation channel can drive several hundred probes, the number of 207 probes per excitation channel is physically limited by the number of lead wires that can be inserted into a single excitation terminal (approximately 10).

The purple lead connects to Analog Ground on the CR10 and Ground on the21X and CR7. The clear lead is the shield and is connected to Ground.

5. PROGRAMMING

Instruction 11 is used to measure temperature, and Instruction 12 measures relative humidity.

Instruction 11 provides AC excitation, makes a single ended voltage measurement, and calculates temperature with a fifth order polynomial. A multiplier and offset of 1.0 and 0.0, respectively, yields output in °C. Temperature in °C is required for temperature compensation in Instruction 12. If temperature in °F is desired, multiply the °C temperature by 1.8 (Instruction 37) and add 32 (Instruction 32) after the relative humidity is measured.

Instruction 12 provides AC excitation, makes a single ended voltage measurement, calculates relative humidity with a fifth order polynomial, and performs the required temperature compensation. Using a multiplier of 1.0 and an offset of 0.0 yields relative humidity in percent.

Example 1 shows the use of Instruction 11 and 12 along with some optional instructions to calculate temperature in Fahrenheit. This is an example only and should not be used verbatim.

EXAMPLE 1. Sample CR10 Instructions for 207 Probe

```
01:          P11       Temp 107 Probe
  01:          1*      Rep
  02:         00*      IN Chan
  03:         00*      EX Chan Option
  04:          5*      Loc :
  05:          1.0     Mult
  06:          0.0000  Offset

02:          P12       RH 207 Probe
  01:          1*      Rep
  02:         00*      IN Chan
  03:         00*      EX Chan Option
  04:          5*      Temperature Loc
  05:          7*      Loc :
  06:          1.0     Mult
  07:          0.0000  Offset

***  Fahrenheit Conversion - Optional ***

03:          P37       Z=X*F                        Multiply Celsius temperature
  01:          5*      X Loc                        in Temp (C) Input Location
  02:          1.8     F                            by 1.8
  03:          6*      Z Loc :                      and store in Temp(F) Input Location

04:          P34       Z=X+F                        Sum
  01:          6*      X Loc                        Result from last instruction
  02:         32.0     F                            and 32.0 to get Fahrenheit
  03:          6*      Z Loc :                      and store again in Temp(F) Input Loc.
```

* Proper entries varies depending on program and datalogger channel usage.

6. MAINTENANCE

The temperature sensor (thermistor) should require no maintenance unless there is physical damage or repeated condensation on the 207 Probe.

In a clean air environment, the PCRC-11 Sensor should perform reliably for up to one year when housed in the 41004-5 12 Plate Gill or UT12PV Radiation Shields. The sensor should be replaced annually when it is operating in typical environmental conditions. In a contaminated or frequently condensing environment, the sensor should be replaced more frequently.

> **NOTE:** CSI's warranty does NOT cover the replacement of the PCRC-11 Sensor if operating the 207 Temperature and RH Probe under harsh conditions.

The PCRC-11 sensor can be purchased separately and easily replaced. Figure 4 shows an assembly drawing of the 207 Probe. The screen to the 207 Probe can be lifted after removing two screws. The PCRC-11 Sensor can then be removed by holding the edges (do not touch sensor surface) and gently lifting up from the sockets, and is installed by gently pushing down into the sockets.

Sulfur and oil gases or compounds will rapidly deteriorate the sensor. Please refer to the attached handling notes provided by Phys-Chem Scientific, Inc.

Liquid water contacting the PCRC-11 Sensor causes a temporary calibration shift resulting in a high reading. As the water evaporates the sensor will return to its original calibration. If liquid water repeatedly contacts the sensor, the gold plated spring clips which hold the sensor become corroded, and the carbon electrode on the polystyrene wafer begins to lift or flake off. If any carbon lifts or flakes away from the wafer, the probe resistance is increased resulting in permanently low readings. At this point, the PCRC-11 sensor should be replaced. Campbell Scientific supplies a protective stainless steel 40 micron screen which impedes liquid water formation on the sensor. Use of this screen is advised, especially in frequently condensing environments and coastal applications.

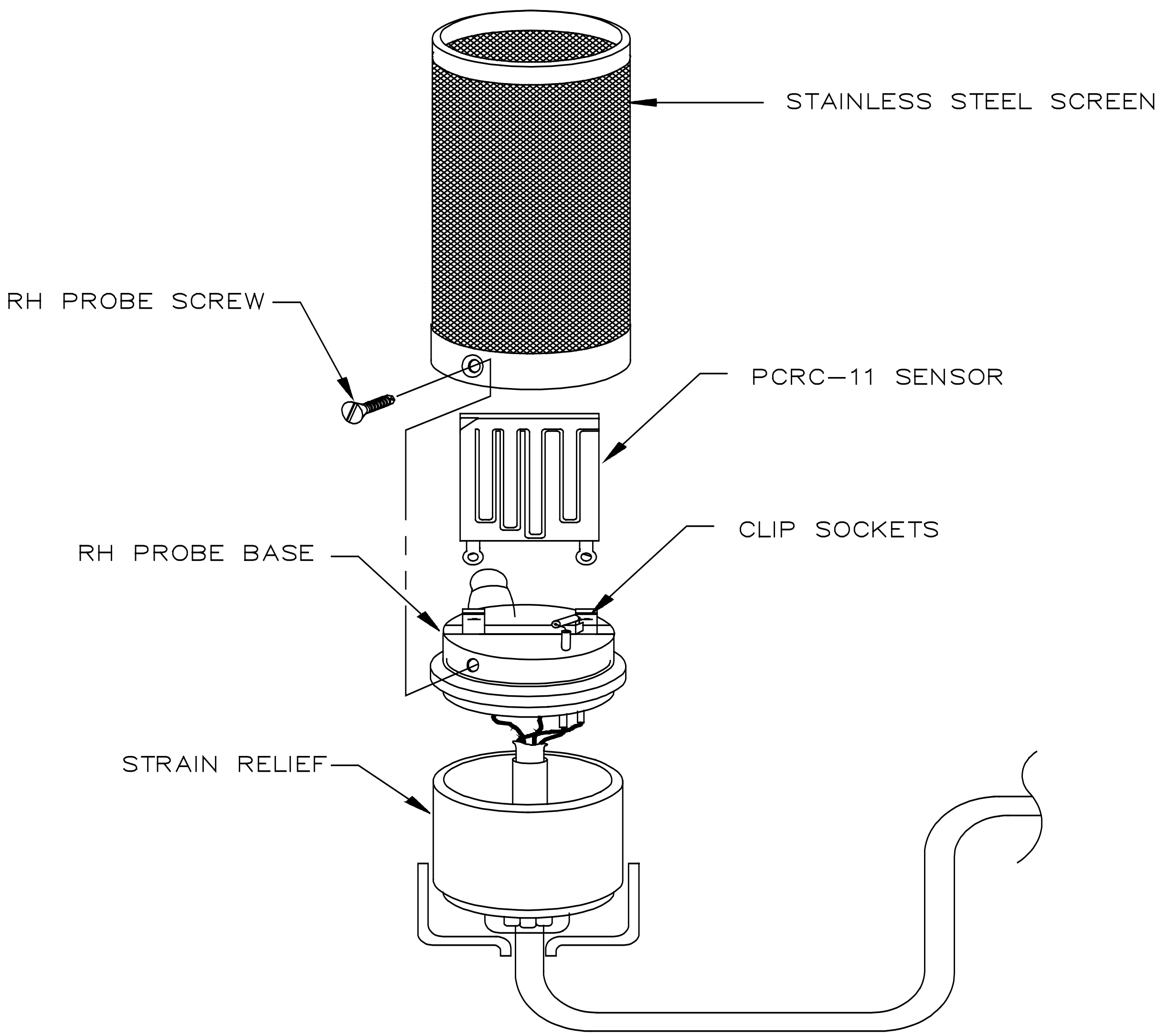

FIGURE 4. 207 Probe Assembly Drawing

7. INSTRUCTION 11 DETAILS

Reading this section is not necessary for general operation of the HMP35C Probe with Campbell Scientific's dataloggers.

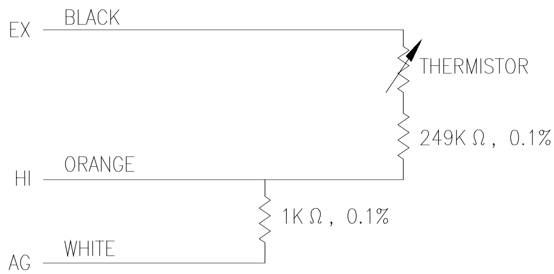

FIGURE 7-1. 107 Thermistor Probe Schematic

Instruction 11 outputs a precise 4V AC excitation (2V with the CR10) and measures the voltage drop due to the sensor resistance (Figure 7-1). The thermistor resistance changes with temperature. Instruction 11 calculates the ratio of voltage measured to excitation voltage (Vs/Vx) which is a direct function of resistance, as shown below.

Vs/Vx = Rf/(Rs+Rf)
= 1000/(Rs+250000)

where, Vx/Vx is the ratio of measured to excitation voltage, Rf is the fixed resistance, and Rs is the sensor resistance.

Instruction 11 then calculates temperature using a fifth order polynomial equation developed by correlating Vs/Vx with temperature. The polynomial coefficients are given in Table 7-1; input to this equation is (Vs/Vx)*800.

Table 7-2 displays resistance and datalogger output at several temperatures.

TABLE 7-1. Polynomial Coefficients

Coefficient	Value
C0	-53.4601
C1	90.807
C2	-83.257
C3	52.283
C4	-16.723
C5	2.211

8. INSTRUCTION 12 DETAILS

Reading this section is not necessary for general operation of the 207 Probe with Campbell Scientific's dataloggers.

Instruction 12 outputs a precise 3V AC excitation (1.5V with the CR10) and measures the voltage drop due to the sensor resistance. The electrical resistance of the conductive path on the PCRC-11 Sensor varies with relative humidity. Instruction 12 calculates the ratio of voltage measured to voltage excitation (V_s/V_x) which is a direct function of resistance, as shown below.

$$V_S/V_X = f(R_S) = R_f/(R_S+R_f) = 1000/(R_S+20000)$$

where, V_s/V_x = ratio of measured to excitation voltage,
R_f = fixed resistance,
and, R_S = sensor resistance.

Instruction 12 then calculates relative humidity using a fifth order polynomial equation developed by correlating V_s/V_x with relative humidity. The polynomial coefficients are given below; input to this equation is (V_S/V_X)*6000.

TABLE 5. Polynomial Coefficients

Coefficient	**Value**
C_0	12.0843
C_1	0.952280
C_2	$-1.420342 \times 10^{-02}$
C_3	1.123239×10^{-04}
C_4	$-4.106548 \times 10^{-07}$
C_5	5.719691×10^{-10}

Table 6 displays resistance and datalogger output at several relative humidities.

TABLE 6. Relative Humidity, Resistance, and Datalogger Output

RELATIVE HUMIDITY %	RESISTANCE OHMS	DATALOGGER OUTPUT %
2	10000000	12.65
4	7200000	12.87
6	5400000	13.12
8	3900000	13.51
10	2800000	14.05
12	2150000	14.61
14	1650000	15.33
16	1250000	16.28
18	960000	17.41
20	730000	18.85
22	550000	20.66
24	420000	22.70
26	318000	25.10
28	242000	27.68
30	185000	30.32
32	144000	32.71
34	112000	34.93
36	86000	36.97
38	68000	38.55
40	54000	40.05
42	43500	41.59
44	35500	43.31
46	28800	45.45
48	23800	47.73
50	20100	49.92
52	17200	52.00
54	14500	54.27
56	12200	56.50
58	10400	58.49
60	9000	60.27
62	7750	62.14
64	6750	63.94
66	5900	65.79
68	5200	67.66
70	4600	69.59
72	4070	71.65
74	3600	73.81
76	3200	75.98
78	2850	78.17
80	2550	80.31
82	2300	82.30
84	2080	84.24
86	1870	86.27
88	1700	88.05
90	1540	89.84
92	1400	91.53
94	1285	92.99
96	1180	94.39
98	1090	95.65
100	1002	96.93

9. ELECTRICALLY NOISY ENVIRONMENTS

If the datalogger is in an electronically noisy environment, the HMP35C temperature measurement should be measured with the AC half bridge (Instruction 5) with the 60 Hz rejection integration option on the CR10 and slowing integration on the 21X and CR7. Instruction 11's fast integration will not reject 60 Hz noise.

Example 2. Sample CR10 Instructions Using AC Half Bridge

```
01:    P5AC Half Bridge
  01:  1 Rep
  02:  22    7.5 mV 60 Hz rejection Range
  03:  1*IN Chan
  04:  1*Excite all reps w/EXchan 1
  05:  2000mV Excitation
  06:  1*Loc [:Air Temp ]
  07:  800Mult
  08:  0Offset

02:    P55Polynomial
  01:  1Rep
  02:  1*X Loc Air Temp
  03:  1*F(X) Loc [:Air Temp ]
  04:  -53.46         C0
  05:  90.807         C1
  06:  -83.257        C2
  07:  52.283         C3
  08:  -16.723        C4
  09:  2.211C5

03:    P4Excite,Delay,Volt(SE)
  01:  1 Rep
  02:  252500 mV 60 Hz rejection Range
  03:  2*IN Chan
  04:  2*Excite all reps w/EXchan 2
  05:  15Delay (units .01sec)
  06:  2500mV Excitation
  07:  2*Loc [:RH      ]
  08:  .1Mult
  09:  0Offset
```

* Proper entries will vary with program and datalogger channel assignments.

** On CR10 the 2500 mV input range and 2500 mV excitation are used.

TABLE 7-2. Temperature, Resistance, and Datalogger Output

Temperature °C	Resistance OHMS	Output °C
-40.00	4067212	-39.18
-38.00	3543286	-37.55
-36.00	3092416	-35.83
-34.00	2703671	-34.02
-32.00	2367900	-32.13
-30.00	2077394	-30.18
-28.00	1825568	-28.19
-26.00	1606911	-26.15
-24.00	1416745	-24.11
-22.00	1251079	-22.05
-20.00	1106485	-20.00
-18.00	980100	-17.97
-16.00	869458	-15.95
-14.00	772463	-13.96
-12.00	687276	-11.97
-10.00	612366	-10.00
-8.00	546376	-8.02
-6.00	488178	-6.05
-4.00	436773	-4.06
-2.00	391294	-2.07
0.00	351017	-0.06
2.00	315288	1.96
4.00	283558	3.99
6.00	255337	6.02
8.00	230210	8.04
10.00	207807	10.06
12.00	187803	12.07
14.00	169924	14.06
16.00	153923	16.05
18.00	139588	18.02
20.00	126729	19.99
22.00	115179	21.97
24.00	104796	23.95
26.00	95449	25.94
28.00	87026	27.93
30.00	79428	29.95
32.00	72567	31.97
34.00	66365	33.99
36.00	60752	36.02
38.00	55668	38.05
40.00	51058	40.07
42.00	46873	42.07
44.00	43071	44.05
46.00	39613	46.00
48.00	36465	47.91
50.00	33598	49.77
52.00	30983	51.59
54.00	28595	53.35
56.00	26413	55.05
58.00	24419	56.70
60.00	22593	58.28

INSTRUCTIONS FOR THE PROPER HANDLING AND USE OF THE PCRC-11 AND PCRC-55 HUMIDITY SENSORS

PHYS-CHEM SCIENTIFIC, INC.
36 WEST 20TH STREET
NEW YORK, NEW YORK 10011, U.S.A.
212-924-2070

MAXIMUM CIRCUIT RATINGS

1. Only AC voltages of at least 20 cycles per second with zero DC component should be used with the sensor (preferably a sinusoidal waveform). Sustained operation on DC voltage or AC voltages with a DC component will result in a shift of calibration; momentary operation on DC voltage may also affect the sensor.

2. Maximum allowable current is 1 mA.

SENSOR HANDLING DO'S AND DON'TS

1. The surfaces of the sensor should not be touched or contaminated in any way.

2. The sensor should be held by its terminals, or by two edges.

3. The sensor should not be exposed to organic solvents and ionic-laden liquids; (any chemical compound that attacks polystyrene may affect sensor performance).

4. For removal of dust or dirt, use a gentle, clean (oil-free) air blast, or brush lightly with a clean, soft, camel's hair brush.

5. Contamination by exposure to oil or oil vapors must be avoided; calibration shift, loss of response time and sensor deterioration may result.

6. The sensor should not be subjected to liquid water immersion, and water condensation on the sensor surfaces should be avoided. While the sensor is not water soluble, water condensation or immersion may affect sensor calibration.

7. The sensors are particularly susceptible to contamination by sulfur gases and sulfur compounds (Do not smoke at the sensor!).

8. It is important to remember that while this sensor is rugged, the nature of its function, the sensing of water vapor, precludes any type of handling that would obstruct or shield its surface from the atmosphere to be sampled.

9. The upper temperature limit of the sensor is approximately 200 °F.

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